Abstract of "Explaining Hoover, Grand Coulee, and Shasta Dams: Institutional Stability and Professional Identity in the USBR"

Dr. Karin Ellison
University of Wisconsin--Madison

Between 1923 and 1943, the US Bureau of Reclamation (USBR) changed dramatically. In 1923, after two decades of operation, the USRS was small and embattled. It had 27 irrigation projects, 3700 full-time employees, and a budget of $20.6 million. In contrast, in 1943, the USBR could have celebrated 20 years of growth and success and anticipated more. In 1943, the USBR had 52 projects. It had increased its staff to 6500, or more than doubled it. Even more impressively, it had increased its budget to $91.7 million, or to almost 4 1/2 times 1922's budget. One of the big changes in the USBR was the construction of large multiple purpose dams—Hoover, Grand Coulee, Shasta, and, after WWII, many more. Multiple purpose dam building, of course, did not arise out of the blue in the 1920s. USBR engineers took utilitarian conservation ideas, espoused by Progressive Era scientists, engineers, and politicians, and implemented them by building large multiple purpose dams.

I explain the advent of multiple purpose dam building, and the growth of the Bureau of Reclamation, in terms of a stable agency leadership and its professional culture. Clearly, the Depression and the New Deal government provided the means that developed rivers, hired new staff, and, generally, fueled agency growth. President Roosevelt, Secretary of the Interior Ickes, Washington Senator Dill, and others involved in directing relief funds to water development did not, however, determine the features of the techno-environmental systems that rivers would become. USBR engineers drew on engineering paradigms, common solutions that could be fitted to new problems, to refine both the production practices and design choices of river development and create these systems. These men gazed at the world through engineers' glasses

and saw disorderly construction sites and disorderly rivers. In response, they applied the tools of their trade and rationalized construction sites and rivers. The result was multiple purpose dams, conservation ideas put into practice, and an expanding USBR.

Biographical data establish the stability of the USBR's leaders in the 1920s and 1930s, their virtually exclusive orientation towards engineering, and links between this group and Progressive Era engineering reforms. Two features of the careers of USBR leaders particularly indicate the stability of the group in the 1920s and 1930s: the long length of their employment with the USBR and the dates and reasons that men left. Education and professional affiliation reveal the group as one of professional engineers. With respect to Progressivism, the biographical data show possibilities. These engineers were in the right places at the right times to be exposed to Progressive ideas about conservation of natural resources and scientific management. They were educated in the Progressive Era. More importantly, these men began their careers at the USBR in its first decade. They trained into their profession under Director Fredrick Newell and Chief Engineer Arthur Powell Davis, both notable figures in the conservation and engineering reform movements.

As with many groups of engineers in this period, this stable group of engineers with links to Progressivism embraced industrial practices and rationalization. They applied these paradigms to both the processes of building dams and to the designing of river systems. To illustrate the industrialized and rationalized elements of dam building and river development plans, I compare these activities with scientific management. I chose Taylorism as a framework for comparison because F. W. Taylor laid out an explicit program for rationalizing workplaces that can serve as a way to distill the broad ranging changes of industrialization and rationalization. Further, Taylorism was broadly discussed and debated in this period, so these concepts would have been part of the intellectual resources of the USBR leaders as they engaged in river planning and directed dam construction. Taylor sought to standardize and routinize everything in a factory—production processes, spatial layout of factories, machines, and, especially, workers. To do this, he created expanded roles for engineers. Not only would mechanical engineers invent and refine factory machinery, but they would also oversee factory operations.

By analyzing the construction methods used at Grand Coulee Dam, I show that the USBR and its contractors set up a process, like Taylorism, that placed engineers in the center, emphasized flow, and refined machinery. During the construction of a dam, USBR employees provided important management oversight through drawings and inspectors. Contractors set up flowing processes construction systems, such as a set of trucks and conveyor belts to remove the "overburden" from the dam site. The USBR employed experts to study and refine the machinery used in the construction of dams, for example concrete mixers.

As with construction sites, Federal engineers developed the ideas about river development, advocated by Progressive Era conservationists, into a set of technical practices, structures, and new landscapes with analysis and management techniques similar to those used by F. W. Taylor and his followers. Like Taylorism, conservation included places for professional engineers in large organizations. Planning and constructing large dams prompted growth of engineering organizations. When engineers changed free-flowing rivers into series of lakes, they used the same kind of spatial logic as Taylor's rearrangement of machinery on factory floors. The USBR's Denver office specialized in designing, analyzing, and refining the main technology of comprehensive river development—multiple purpose dams—just as Taylor worked on making faster and more precise machine tools. While Taylor stretched rationalization to encompass workers, comprehensive planning stretched rationalization to encompass another new area—large natural systems.

Explaining Hoover, Grand Coulee, and Shasta Dams: Institutional Stability and Professional Identify in the U.S. Bureau of Reclamation

Dr. Karin Ellison
Instructor
University of Wisconsin, Madison
July 2001

When Interior Secretary Hubert Work called for an investigation and reorganization of the U.S. Reclamation Service (USRS)[1] in 1923 and Interior Secretary Harold Ickes repeated the exercise in 1943, the institution that they targeted could hardly have been more different. In 1923 after two decades of operation, the USRS was small and embattled. By 1922, it had constructed 27 irrigation projects, had 3667 full-time employees, and $20,603,793 in funds to spend. Its major constituency, the farmers who worked the USRS's irrigated land, was in open revolt. The cost of creating irrigation farms had far exceeded rosy government estimates and, with the revival of European agriculture in the wake of W.W.I, markets for American farmers collapsed. In contrast, in 1943, the USBR could have celebrated 20 years of growth and success and anticipated more. In 1943, the USBR had 52 projects. It had increased its staff to 6543, or more than doubled it. Even more impressively, it had increased its budget to $91,665,613, or to almost 4 1/2 times 1922's budget. Further, this growth included the construction of Hoover,[2] Grand Coulee, and Shasta dams-the first set of monumental multiple purpose structures and the entree to integrated development of rivers after World War II.[3]

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[1] As part of the reorganization, the USRS's name was changed to the U.S. Bureau of Reclamation (USBR). Throughout this paper, I will use USRS to refer to events and periods before 1923 and USBR to refer to events and periods in 1923 or later and to refer to things which fall into both periods.

[2] Called Boulder by USBR engineers from 1918, the Interior Secretary named this dam Hoover when he announced its construction in 1930. The next Interior Secretary, Harold Ickes, changed the name back to Boulder Dam in 1933. Congress restored the name Hoover Dam in 1947. William E. Warne, The *Bureau of Reclamation, Praeger library of U.S. Government departments and agencies, no. 34 (New* York: Praeger Publishers, 1973), 36. For simplicity, I will refer to it as Hoover Dam throughout.

[3] Figures come from *Twenty-First Annual Report of the U. S. Reclamation Service, 1921-22* (Washington, D.C.: GPO, 1922); "Annual Report of the Bureau of Reclamation," in *Annual Report of the*

Given the weakness of the USRS as an organization in the early 1920s, the institutional success of the USBR in the 1930s and 1940s begs explanation. The Depression is surely part of the story. The severe economic problems of the 1930s and the willingness of Franklin Roosevelt's administration to spend money in an attempt to solve them provided great opportunities for men with plans. However, dams were not the only way, or even a particularly important way, for the federal government to spend money.[4]

One might argue that the multiple purpose dams themselves adequately provided the rest of the story of the USBR's success. The concept of a multiple purpose dam is clearly well suited to the American political system. Each dam offers a range of services-navigation improvement, irrigation water, flood control, and hydroelectricity, most commonly. Each service can have a constituency and each constituency one or more votes to fund a dam in Congress. However, in the early 1920s, multiple purpose dams were much more an idea than a reality. Engineers had reported favorably on a proposal to build Hoover Dam on the lower Colorado River. However, neither the compact dividing the waters of the Colorado between the tributary states nor the political coalition, which would wrest approval and funding for Hoover Dam from Congress, yet existed. The Army Corps of Engineers had built a hydroelectricity dam and two nitrate plants at Muscle Shoals on the Tennessee River during World War I. Congress, however,

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Secretary of the Interiorfor the fiscal year ended June 30, 1943. (Washington, D.C.: GPO, 1943); and Karin Ellison, "The Making of a Multiple Purpose Dam: Engineering Culture, the U.S. Bureau of Reclamation, and Grand Coulee Dam, 1917-1942" (Ph.D., Massachusetts Institute of Technology, 2000), 265-6. I use 1922 because the USBR did not report personnel statistics in its annual report between 1923 and 1936. For a discussion of the 1923 investigation and the status of projects at that time see: Brain Q. Cannon, ""We are Now Entering a New Era": Federal Reclamation and the Fact Finding Commission of 1923- 1924," *Pacific Historical Review 66* (May 1997): 185-211.

would fight over how to dispose of these seeds of the Tennessee Valley Authority until Franklin Roosevelt took office in 1933.[5]

People, as much as money and a new technology, explain the successes of the USBR in the 1920s and 1930s. In this period, a remarkably stable and homogeneous group of men[6] led the USBR. In the first part of this paper, I will show that overwhelmingly the leaders of the USBR between 1923 and 1943 were engineers familiar with Progressive reform engineering. In the second part, I will suggest that the training and professional identification of USBR leaders as Progressive engineers made a significant impact on its development. USBR leaders used experience with and enthusiasm for industrialization, scientific management, and conservation to reshape the organization's activities. Conservation provided a broad conceptual framework for water development by pairing "comprehensive planning" with reservoir construction. Industrialization and scientific management emphasized process-place engineers at the center and study and refine all processes and components.[7]

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[4] On the place of dam building in New Deal policy see: Ellison, "Making of a Multiple Purpose Dam," 193-226.

[5] On Hoover Dam see: Norris Hundley, Jr., "The Politics of Reclamation: California, the Federal Government, and the Origins of the Boulder Canyon Act-a Second Look," *California Historical Quarterly* 52 (1973): 292-325 and Joseph E. Stevens, *Hoover Dam: An American Adventure* (Norman: University of Oklahoma Press, 1988). On the origins of the TVA see: Paul K. Conkin, "Intellectual and Political Roots," in *TVA: Fifty Years of Grass-Roots Bureaucracy,* ed. Erwin C. Hargrove and Paul K. Conkin (Urbana: University of Illinois Press, 1983), 3-34 and Preston J. Hubbard, *Origins of the TVA: The Muscle Shoals Controversy, 1920-1932* (Nashville: Vanderbilt University Press, 1961).

[6] The USBR leaders were virtually all male-166 of 167. Given their overwhelming maleness, I will refer to the USBR leaders as men.

[7] I would like to thank Deborah Fitzgerald for sharing a copy of her forthcoming book: Deborah Fitzgerald, *Yeoman No More: The Industrialization of Agriculture in America (New* Haven: Yale University Press, forthcoming). She argues that one factor in the industrialization of American agriculture was the work of agricultural engineers. These engineers took the farm as the focus of their profession and encouraged changes that mirrored Taylorism. The second part of this paper is an extension of that argument to the civil engineers employed by the USBR between 1923 and 1943. Of course, the limits of and errors in the extension of Fitzgerald's argument are my own doing.

Engineering Leaders

One of the most striking features of the USBR between 1923 and 1943 was the stability and uniformity of its leadership. USBR leaders devoted their careers to government service. Overwhelmingly, they came to the USRS during the Progressive Era with strong ties to engineering through education and professional affiliations.

The organization chart appearing in the USBR's monthly magazine *Reclamation Era* identified the small groups of key figures in the commissioner's office in Washington, D.C. and the chief engineer's office in Denver, Colorado, as well as a larger group of men heading the various irrigation projects and investigations across the West. Standard biographical data, such as found in *Who's Who* and other common biographical sources, was available for 53 of the 167 individuals so identified.[8] The field engineers were by far the largest group.' 125 men held high positions in field offices as opposed to 24 men in Denver and 17 men and one woman in Washington, D.C. However, information was much more readily available on leaders from the commissioner's office and from the chief engineer's office than on field men. Data on 13 individuals from the Washington group and 20 from the Denver group provided information on over 70% of

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[8] Except for the small number of people clearly identified as legal or clerical staff, the 167 individuals are all the individuals found by checking this tabulation once each year between 1923 and 1943. I omitted the legal and clerical staffs because they are identified small divisions of the USBR separate from the main organization. I generally checked tabulations from January or December issues of *Reclamation Era*. Breaks in publication during the worst of the Depression and during W.W.II, as well as decisions made in binding the set of *Reclamation Era* to which I had access while researching this paper, account for variations from this general approach. The specific volumes I consulted were: June 1923, Jan. 1924, Dec. 1924, Dec. 1925, Jan. 1927, Dec. 1927, Jan. 1929, Jan. 1930, Jan. 1931, Jan. 1932, Jan. 1933, Feb. 1935, Jan. 1936, Jan. 1937, Jan. 1938, Jan. 1939, Jan. 1940, Jan. 1941, and Jan. 1942.

[9] I assigned each leader to a group by the highest office in which he served during this period. Harry Bashore, for example, worked for the USBR for 39 years advancing from a junior engineer on the North Platte Project to commissioner. He appears in the Washington, D.C. category because his highest position between 1923 and 1943 was as assistant commissioner in Washington.

these leaders. The additional 20 field men identified only allow analysis of 16% of this group.[10]

The career paths of USBR leaders established a remarkable stability in this group between 1923 and 1943. The longevity of these men as USBR employees paired with when and why they left the USBR indicates the stability of this group. Many of these men worked for the USBR for lengthy periods. Field engineer Frank Banks, who oversaw the construction of Owyhee and Grand Coulee dams, set the challenge with 5 1 years of service. While few rivaled Banks, 25 additional men spent 20 years or more as employees of the USBR. This pattern of lengthy service is particularly striking when compared with other groups of federal experts. In agricultural economics, for example, men used employment in the U.S. Department of Agriculture’s Bureau of Agricultural Economics in lieu of graduate school. Many of the Bureau of Agricultural Economics’ early staff only worked there briefly.”

The small number of USBR leaders who departed between 1927 and 1942—10—and the reasons they left further indicates stability. Many of these leaders did not leave by choice. Seven of the men died while employed by the USBR. The men in the USBR pushed out the one woman in the group, Mae Schnurr. Schnurr worked her way up through the federal bureaucracy to a position of responsibility under Commissioner Mead-assistant to the commissioner and, on occasion, acting commissioner. After Mead died in 1936, Schnurr was repeatedly demoted until she arranged a transfer to the Office of the Secretary of the Interior in 194 1. Even the two leaders who willingly left did not make significantly different career choices. One retired

[10] All biographic and quantitative data on USBR leaders comes from the sources listed in Table 1.

and the other transferred to a very similar position with the Tennessee Valley Authority (TVA).‘*

A clearly defined group of 10 engineers did leave the USBR between 1924 and 1926—fallout from reorganization. The Interior Secretary pushed Director Arthur Powell Davis out of the USRS in 1923.[13] He replaced A. P. Davis with David W. Davis, a banker and politician from Idaho. After brief period of reorganization, D. W. Davis was one of the early 1920s departers. A second, Morris Bien, retired in 1924 at age 65 to pursue a private law practice. The rest followed Chief Engineer Weymouth. Weymouth resigned in 1924 as Elwood Mead, an engineer, replaced David Davis. After slightly over one year in private practice, Weymouth went on to work as chief engineer for J. G. White Engineering Corporation from 1926-29, for the City of Los Angeles Water Works from 1929-30, and for Southern California's Metropolitan Water District (MWD) until he retired. All seven of the other men who left the USBR between 1924 and 1926 worked with Weymouth at one or more of these three organizations.[14]

A stable group, these men also made a very homogeneous group. Homogeneity started at home. Geographically, Commissioners Mead and Page and Chief Engineer Walter all hailed from the Midwest or Plains states and they exemplified a trend. In all,

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[11] Fitzgerald, *Yeoman No More*, *43-4*.

[12] Porter Johnstone Preston retired in 1940. Robert Ansley Monroe transferred to the TVA in 1937. Indeed, given the technical collaboration between the USBR and the TVA in the 1930s, surprisingly few men made Monroe's choice. The USBR's Denver office designed Norris and Wheeler dams for the TVA. When these dams went into construction and TVA established its own design team, the new organization was willing to hire men from the USBR. For a very brief mention of the USBR's work for TVA, see: Edgar C. McMechen, "The Billion Dollar Engineer," *Reclamation Era* 27 (April 1937): 82-84.

[13] The head of the USRS was a director rather than a commissioner.

[14] On the reorganization in 1923-4, see: Cannon, "Entering a New Era."

22 of 53 USBR leaders, or 42%, came from this region. The Reclamation West[15] and Northeast evenly split a second 20. Only three men came from each the South and Europe. This geographic distribution, however, shifted over time. When I divided the 53 USBR leaders by both birth decades and hiring decades, the 11 born in the 1890s and 1900s and the 13 hired in 1923 or later more strongly represented the Reclamation West. In these divisions, 36% and 38% respectively came from federal irrigation states.

In respect to marriage and children, USBR leaders were even more uniform and conservative. The large majority married and had children. Commissioner Mead, for example, married Florence Chase in 1882 and, after she passed away, married Mary Lewis in 1905. In all, Mead had six children. While most USBR leaders had fewer children: biographical sources identified none as life-long bachelors and only three as childless. Information on family, however, was reported less frequently than many of the data on these leaders. No information on marriage or children appeared for roughly 1/3 of these individuals.

Similarities multiplied at work. The typical USBR leader was born in the 1880s (42%), attended a land-grant university (70%), majored in civil engineering (42%), completed his education with a bachelor's degree (62%), began working in the Progressive Era (74%), belonged to the American Society for Civil Engineers (62%), worked for the USBR for 20 years or longer (68%), and ended his career at the USBR (5 1%). A closer look at this data suggests not just similarities, but patterns linking USBR leaders to Progressivism and engineering reform more specifically.

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[15] The original states in which the USRS operated were Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota,

USBR leaders were Progressive engineers. Dates of birth, education, first employment, and hiring by the USRS place the beginning of these men's careers firmly in the Progressive Era. The first leaders of the USRS pursued reform goals and taught the leaders of the 1930s and 1940s their jobs in an atmosphere of activism. Further, the careers of the latter group demonstrated a commitment to public service indicative engineering reformers.

Dates place the USBR leaders of 1923- 1943 as young professionals during the Progressive Era. USBR leaders were born between 1858 and 1905. The largest portion was born in the 1870s (9) and, especially, the 1880s (22). Age meant that the men attended college and began their careers in the Progressive Era. 3 1 of 53 graduated with a bachelor's degree between 1900 and 1919. The addition of the few men who did not have a college degree and those for whom education information is not available meant that even more began working in these two decades-39 of 53.

More specifically, the leaders of the 1920s and 1930s began working for the USRS in the reformist atmosphere of its first decade. The USRS hired 34 of 53 between 1902 and 1912—the first decade of the organization's existence. In these early years, reform minded men led the USRS and trained the future leaders into their profession. Before 1923, the USRS had two heads-Frederick Haynes Newell and Arthur Powell Davis. Both these men began their careers in the U.S. Geological Survey under John Wesley Powell, a colorful explorer, administrator, and founder of the conservation movement. Newell helped Nevada Senator Newlands and other western senators draft the Reclamation Act and became the first director of the USRS. He was a leader of the

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Utah, Washington, and Wyoming. Texas was added in 1906. Michael C. Robinson, *Water for the West:*

conservation movement and, as part of the major effort of Progressive engineers directed at their own profession, advocated unifying engineers in one professional society through his Committee on Cooperation and the American Association of Engineers. In 19 14, a financial house cleaning in the USRS led to Newell's firing. Newell's chief engineer and Powell's nephew, Arthur Powell Davis, moved into the top leadership position, Davis too pursued conservation. He formulated an early reform tradition plan for the development of the lower Colorado River. [16]

A commitment to government service evident in the careers of the USBR's second generation of leaders suggests that these men did indeed adopt some of the values of their mentors. Both career paths and number of years spent in the USBR show a commitment to government engineering. Of 53 men, 3 l-over half-either spent their entire career with the USBR or ended it there. Another 13 gave long periods of service at the beginning or in the middle of careers. Only five worked for the USBR for less than 10 years.

Unlike one strain of Progressive engineering reformers, USBR engineers demonstrated a commitment to government service without condemning corporations or corporate work. Morris Cooke represented the anti-corporate strain in engineering reform. A member of the inner circle of the founder of "scientific'management" F. W.

The Bureau of Reclamation 1902-1977 (Chicago: Public Works Historical Society, 1979), 17-18.

[16] "Newell, Frederick Haynes," in *The National Cyclopaedia of American Biography* (New York: James T. White and Company, 1933), 162-163; Donald C. Jackson, "Engineering in the Progressive Era: A New Look at Frederick Haynes Newell and the U.S. Reclamation Service," *Technology and Culture 34* (July 1993): 539-74; Edwin T. Layton, *The Revolt of the Engineers: Social Responsibility and the American Engineering Profession* (Cleveland: The Press of Case Western Reserve University, 1971), 109-127; "Davis, Arthur Powell," in *The National Cyclopaedia of American Biography, Vol. 24* (New York: James T. White and Company, 1935), 116-l 17; Gene M. Gressley, "Arthur Powell Davis, Reclamation, and the West," *Agricultural History* 42 (1968): 241-257; Hundley, "Politics of Reclamation;" and Ellison, "Making of a Multiple Purpose Dam," 70-77.

Taylor, Cooke began his career by applying scientific management ideas to the running of a government agency, as Director of Public Works in Philadelphia, and to the operation of a professional society, the American Society of Mechanical Engineers. These efforts convinced Cooke of the dishonesty of corporations, and especially electrical and other utility companies. He campaigned against utility influence in the American Society of Mechanical Engineers in the mid- 19 1 0s and, in the New Deal, headed the Rural Electrification Administration, one of Roosevelt's efforts to curb the excesses and go beyond the self-imposed limits of electrical utilities.[17]

USBR leaders, in contrast, worked closely with corporations in relevant fields and did not see former corporate employment as a ban to a job in the USBR. Starting in 1925, the USBR organized most of its major construction work by contract and, as a result, worked closely with corporate executives and engineers. For example, between 1934 and 1943 two successive groups of general contractors made Grand Coulee Dam a massive and concrete reality from a set of plans.[18] A consortium of Silas Mason Company of New York; Walsh Construction Company of Davenport, Iowa; and Atkinson-Kier Company of San Francisco won the first contract. Kaiser Construction Company of Seattle, Morrison Knudsen Company of Boise, Utah Construction Company of Ogden, J. F. Shea Company of San Francisco, Pacific Bridge Company of San Francisco, McDonald and Kahn of San Francisco, and General Construction Company of

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[17] Layton, *Revolt of the Engineers,* 154-178 and Deward Clayton Brown, *Electricity for Rural America: The Fight for the REA, Contributions in Economics and Economic History, no.* 29 (Westport: Greenwood Press, 1980).

[18] I use Grand Coulee Dam as an example throughout this paper because it was one of the USBR's largest undertakings in the 1920s and 1930s. Also, as a major undertaking following and overlapping Hoover Dam examples from its construction illustrates how the USBR institutionalized some of the practices used for Hoover Dam. For more complete accounts of the planning and construction of Grand

Seattle joined the first group to complete construction. Below I describe how USBR engineers and their contractors interacted during routine construction and how they could collaborate to experiment on, and improve production processes. In terms of careers, many USBR leaders-32 or almost 2/3s—worked for private companies at some point in their careers. A handful worked for the large electrical companies Cooke and other reformers found especially repugnant. For example, Leslie McClellan, the USBR's chief electrical engineer, worked briefly for Southern California Edison. Robert Monroe, another Denver office man, worked for Pacific Gas & Electric before coming to the USBR.[19]

Between 1923 and 1943 a remarkably stable and homogeneous group of men steeped in Progressive Era reform movements provided the leadership for the USBR. Additionally, the ties between these men, the USBR, and engineering cannot be overstated. The domination of the USBR by civil engineers, rather than experts on water resources or irrigated agriculture, was a contingent historical phenomenon. Other groups with technical expertise critical to the planning, construction, and operation of irrigation projects were available as choices to staff the new USRS. Experts in the U.S. Geological Survey, with stronger ties to geology, hydrography, and geography than to civil engineering, dominated federal debates over irrigation in the nineteenth century. Experts in the U.S. Department of Agriculture worked with Wyoming Senator Francis E. Warren to prepare an alternative to the bill prepared by Senator Newlands and engineer Newell, which created the USRS. Still, engineers, rather than experts in other related areas, led

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Coulee Dam see: Ellison, "Making of a Multiple Purpose Dam" and Paul C. Pitzer, *Grand Coulee: Harnessing A Dream* (Pullman, Washington: Washington State University Press, 1994).

the USBR. The structure of the USBR, the fields of education of USBR leaders, and the professional affiliations of these men show their disciplinary ties to engineering generally, and civil engineering in particular. Further, these leaders had much in common with other engineers in this period: regional affiliation, educational institutions, level of education, and international work.[20]

An organization chart from the 1920s or 1930s immediately reveals the importance of engineering in the USBR. The USBR was a very strict hierarchical organization with engineers in all leadership positions, except for a small legal branch parallel to the main engineering organization. Physically, space separated the USBR engineers. A commissioner and a small staff led the USBR from Washington, D.C. By far, however, most of the employees and leaders worked in the West. The chief engineer's office in Denver served as the technical hub for the USBR. In addition, each irrigation project had a field office.

A commissioner-typically with substantial engineering experience-led the USBR. From Washington, D.C., commissioners and their small staff primarily interacted with others in the capital-members of Congress, Interior Secretaries, and other upper-administration officials. The USBR had three commissioners between 1923 and 1945. David W. Davis broke virtually all USBR patterns. Interior Secretary Hubert Work appointed this banker and former governor of Idaho commissioner in hopes that a

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[19] "Reclamation Engineering Number," *Reclamation Era* 30 (July 1940): 193. For descriptions of construction Hoover and Grand Coulee Dams, see: J. E. Stevens, *Hoover Dam* and Pitzer, *Grand Coulee.*

[20] On the U.S. Geological Survey in the nineteenth century, see: Thomas G. Manning, *Government in Science: The U. S. Geological* Survey, 1867-1894 (University of Kentucky Press, 1967) and A. Hunter Dupree, *Science in the Federal Government: A History of Policies and Activities to* 1940 (Cambridge: Belknap Press of Harvard University Press, 1957), 195-214 and 232-236. On irrigation in the nineteenth century and the creation of the USRS, see: Donald J. Pisani, *To Reclaim a Divided West: Water, Law, and*

businessman could place the USRS on a more sound financial footing. Davis only stayed with the USBR for a few years. Engineering training and long careers in public service made the other two commissioners typical of leaders of the USBR. Elwood Mead took the commissioner's office in 1924. It was his final position in a lengthy career in water resources. After working on a survey team during his teenage years, Mead earned a bachelor's and master's at Purdue University and a bachelor's in civil engineering at Iowa State College in the early 1880s. A short tenure as professor of irrigation engineering at Colorado Agricultural College led to the position of State Engineer of Wyoming during the 1890s. In Wyoming, Mead participated in writing water law that made the state the sole owner of all water. This legislation became the basis for revising water rights doctrine in several western states. Subsequently, Mead promoted irrigated agriculture through the following positions: director of irrigation investigations in the U.S. Department of Agriculture; chairman of the State Rivers and Water Supply Commission in Victoria, Australia; and director of the state planned irrigation communities at Durham and Delhi, California. He also worked as a professor at University of California, Berkeley. When Mead died in 1936, Interior Secretary Harold Ickes appointed civil engineer John C. Page acting commissioner and then commissioner. Page was a much less well-known engineer. Other than a year as assistant city engineer of Grand Junction, Colorado, Page spent his entire career in USBR. His training consisted of a bachelor of science from University of Nebraska and a year of graduate study at Cornell University.

Public Policy, 1848-1902, Histories of the American Frontier (Albuquerque: University of New Mexico Press, 1992), 273-325.

Page's work in the early 1930s as the second in charge of the field office for Hoover Dam moved him from USBR staff to USBR leadership.[21]

Designation of a chief engineer as the USBR's second-in-command further focused the USBR around engineering. The chief engineer held final authority for all technical matters-construction, design, and research-but focused on overseeing construction. Denver, Colorado housed the chief engineer and his engineering staff, which grew dramatically between 1923 and 1943. In the early 1920s, a few senior engineers coordinated USBR engineering from Denver. By the 1930s, a leadership staff of 9-an assistant chief engineer, a chief designing engineer, an assistant chief designing engineer, a chief electrical engineer, a designing engineer of dams, a designing engineer of canals, a mechanical engineer, and an engineer on technical studies-oversaw a staff of over 750.[22]

Three men held the job of chief engineer between the 1923 and 1943. Like the commissioners, in both education and public service, the chief engineers had strong links to engineering and engineering reform. A civil engineer from the University of Maine (1896), Frank Weymouth served his last of 22 years with the USBR in 1924. When Weymouth left, Chicagoan Raymond (Ray) Walter became chief engineer. Walter joined the USRS as a freshly minted civil engineer from Colorado State College in 1903, one-year after conservationists and western congressmen created the USRS. He held the

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[21] For a brief description of the responsibilities of the commissioner, chief engineer, and project managers, see "Division of Functions of Bureau put into Effect," *Reclamation Record* 14 (November-December 1923): 312. In addition, Warne, *Bureau of Reclamation,* 21-25 describes the function of the commissioner's office in the early 1970s. While the subdivisions within the Interior Department and the USBR's Washington, D.C. office differed in the 1920s and 1930s from those described by Warne, the basic tasks were the same.

[22] Warne, *Bureau of Reclamation,* 25-27 and Robinson, *Wuterfor the West,* 56, 71-73, and 75.

position of chief engineer from 1924 until his death in 1940. Walter's long-time assistant chief engineer and another career USBR man, Sinclair Ollason Harper, held the top position in Denver from 1940 to 1944. Harper received his bachelor's in civil engineering from the University of California.

After the chief engineer, the most important man in Denver was John (Jack) Savage, the chief designing engineer. While Chief Engineer Walter focused on construction, Savage oversaw all aspects of design, planning, and research in the USBR. Savage too followed the typical education and career pattern. Except for eight years with a small consulting engineer firm, Savage spent his entire career with the USBR. His formal training consisted of a bachelor of science in civil engineering from the University of Wisconsin. Savage's achievements, however, exceeded most USBR engineers.' He held three honorary doctorates. The National Academy of Sciences and the American Academy of Arts and Science elected him a member. The four engineering founder societies-the American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers and the American Institute of Electrical Engineers-awarded Savage the John Fritz Medal for notable achievement in 1945. In addition, the Concrete Institute awarded him its Turner gold medal for his work on hydraulic structures.

Beyond the central staffs in Washington, D.C. and Denver, the USBR detailed engineers to oversee construction and operation of projects. This group-the largest by number-consisted of surveyors, construction inspectors, and "office engineers." These last drafted, made cost estimates, and performed other engineering office tasks. Frank

Banks, described by Chief Engineer Walter as "our best construction engineer,"" followed the education and career path of other USBR leaders. Banks studied for his degree in civil engineering at the University of Maine. He joined the USRS immediately upon graduation in 1906 and retired in 1957, after 5 1 years of service. He supervised the construction of several USBR major dams including Owyhee Dam in Oregon in the 1920s and Grand Coulee Dam in Washington State in the 1930s.[24]

Finally, the USBR hired consulting engineers to monitor major construction endeavors like Hoover and Grand Coulee dams. These men met as a board a couple of times a year to review designs and specifications, to inspect the quality of the work and procedures, and to provide opinions on issues raised by the USBR regular staff. For example, the USBR's consulting board for Grand Coulee Dam consisted of Columbia University Professor of Geology Charles Berkey, retired Stanford Professor of Mechanical Engineering and Fluid Mechanics William Durand, Seattle consulting engineer and former USBR employee Joseph Jacobs, and Dayton, Ohio, consulting engineer Charles Paul, also a former USBR engineer.[25]

The education and professional affiliations of USBR leaders cemented the connection between the engineering organization and the broader profession of civil

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[23] R. Walter to E. Mead, telegram, 28 July 1933, 478:101.03, Entry 7/30-45-CBP, WDC, RG 115. See Table 2 for abbreviations used in footnotes.

[24] The USBR engineers compiled "Annual Project Histories," which, in part, described field staff and their activities. See, for example, USBR, "Columbia Basin Project: Annual Project History," vol. 1, 1934, Entry 10, WDC, RG 115. "H. A. Parker Now Irrigation Engineer, Columbia Basin Project," *Reclamation Era* 29 (January 1939): 20 also describes the work of a field engineer. F. A. Banks, "Problems in Handling Large Construction Work by Contract," New *Reclamation Era* 20 (December 1929): 182-5 describes the tasks and pitfalls of serving as a project superintendent.

[25] The "Annual Project Histories" also describe the activities of the consulting boards. See, for example, USBR, "Columbia Basin Project," 1934, Entry 10, WDC, RG 115, 35-37. See also: "Berkey, Charles Peter," in *Who Was Who in America, vol.* 3 (Chicago: Marquis Who's Who, 1960), 70; "Durand, William Frederick," in *Who Was Who in America,* vol. 3 (Chicago: Marquis Who's Who, 1960), 244; and

engineering. USBR men primarily chose civil engineering as their field of education-22 men or 42%. Another 13 men selected other engineering fields. Electrical and mining at four each were the best represented. The single man with topographical engineering as a major suggests the weakness of remaining ties to the disciplines of the U.S. Geological Survey. Unfortunately, biographical sources did not reveal the field of study for more than 20% of the USBR leaders.

Participation in professional societies maintained the connection to engineering, and especially civil engineering. USBR leaders belonged to honor societies, professional organizations, and social clubs for engineers. Tau Beta Pi (an engineering honor society), Chi Epsilon (the civil engineering honor society), and Sigma Xi (a science and engineering research honor society) elected 13 USBR leaders as members. 37 men (70%) belonged to at least one professional organization. By far, the American Society of Civil Engineers claimed the most USBR men-33. Societies representing other areas of engineering, such as the American Institute of Electrical Engineers (5) and the American Concrete Institute (5), only claimed a handful of men. Roughly one-quarter of the men also belonged to regional organizations for engineers and scientists. Among these were the Colorado Society of Engineers (7), the Commonwealth Engineers Club in San Francisco (3), and the Cosmos Club in Washington D.C. (3). Membership in professional organizations associated with geology and agriculture again show only very weak ties between USBR leaders and these closely related areas of expertise. Two of the leaders belonged to American Geophysical Union and one of these men also belonged to American Meteorological Society. One additional man belonged to the semi-popular

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"Paul, Charles Howard," in *Who Was Who in America,* vol. I (Chicago: The A N Marquis Company, National Geographic Society. In terms of agriculture, only three men belonged to the American Society of Agricultural Engineers (ASAE).

The similarities between USBR leaders and other groups of engineers further show how engineering dominated the USBR. The best quantitative information on another group of American engineers in the 1920s and 1930s comes from Deborah Fitzgerald's Yeoman *No* More. Fitzgerald describes agricultural engineers and these men shared many, but not all, characteristics with USBR leaders. Fitzgerald reports on a group of founders, officers, or council members of the ASAE between 1907 and 1930. The founders were men of the same generation as the USBR leaders. They were born in the 1880s and attended college in the first decade of the twentieth century. They also took degrees in engineering fields and, far from rejecting business ties, moved easily in and out of commercial employment. Further, both groups overwhelmingly attended the same kinds of institutions of higher education, finished their education at the same level, and worked internationally for part of their careers.[26]

The tie between USBR leaders, engineers more generally, and engineering reform was to a type of education institution and the profession generally, rather than one specific university. USBR leaders attended state schools-37 or 70%. They chose universities all across the West and Midwest. ASAE founders likewise chose land-grant schools, although all midwestern. Neither group came out of a unique strong department at a single university. Two groupings, however, did exist among USBR leaders. Six men came from the University of Maine. Frank Weymouth-later chief engineer and clearly more of an institution builder than many in the USRS-returned to his alma mater,

1942), 945.

Maine, to speak about his work with the USRS in 1904. His visit recruited Francis Crowe to work for the USRS that summer (and Crowe would return after graduation). The following school year Crowe spoke about the West and reclamation with enthusiasm. The tales of Weymouth and Crowe led several other young men from Maine to join the USRS.[27] Less surprising, given the location of the chief engineer's office, a group of men also came to the USBR from the universities in or near Denver. Three took undergraduate degrees at Colorado State College, two at the Colorado School of Mines, and one at the University of Colorado.

In level of education, USBR leaders followed general patterns for engineering. For many of the men, 72%, the bachelor's degree completed their formal education. Likewise, Fitzgerald found that a substantial portion of ASAE founders and leaders had college degrees. USBR men in the commissioner's office, as a group, did have more education than their USBR peers or ASAE leaders. Two held a second bachelor's degree and three held master's or professional degrees. One additional man had done one year of graduate work. These men were six of the 11 total who had undertaken schooling beyond the bachelor's and 46% of the 13 individuals from the Washington Office.

Many American technical professionals of the early decades of the twentieth century consulted or worked internationally. Fitzgerald examines the experience of agricultural experts in the Soviet Union. 20 USBR leaders-five from the Washington office, nine Denver office men, and six of the men from field offices-worked internationally too. They worked on a range of international projects, These included

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[26] Fitzgerald, *Yeoman No More, 82-86.*
[27] S. 0. Harper, Walker R. Young, and W. V. Greeley, "Francis Trenholm Crowe, Hon. M. ASCE," *ASCE Transactions* 113 (1948): 1397-8.

planning irrigation communities in Australia, building waterworks in Mexico, and working on the Panama Canal. The Near East, Far East, British Empire, and Central and South America all provided opportunities for USBR men.[28]

In all, a special group of men led the USBR during the 1920s and 1930s. All of the USBR's main hierarchy-commissioners, chief engineers, Denver office department heads, and the top staff of large projects-was a stable and uniform group of men affiliated with engineering and, more particularly, Progressive engineering reform. Long tenure of USBR leaders created stability and few departures in the late 1920s and 1930s, in particular, reinforced this trend. The USBR uniformly hired western or midwestern family men for its leaders. Strong patterns in education and career paths further demonstrated the uniformity of the group and linked them to engineering and, especially, Progressive engineering reform. Virtually all of these men finished their formal education with undergraduate degrees in engineering from land-grant universities during the Progressive Era. They maintained ties to engineering through professional societies, most commonly the American Society of Civil Engineers. Long careers in public service further suggests they adopted values of their engineering reform mentors. USBR leaders did not, however, belong to the anti-corporate wing of Progressive reform engineering. The USBR worked closely with corporate contractors and many USBR leaders worked for private companies at some point in their career.

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[28] Fitzgerald, ***Yeoman No More,*** 179-207.

Engineering Rivers

This group of stable and uniform Progressive engineers drew on the important experiences of their disciplines as they remade the USBR in the 1920s and 1930s. The sibling Progressive reform movements of conservation and scientific management, as well as industrialization more generally, were the most important of these experiences. USBR men used scientific management, and some of the more general principles of industrialization, to refine conservation and create both industrialized dam construction and industrialized rivers.

Over the nineteenth century, industrialization fundamentally changed the production of goods and ways of life in the United States. Items made by artisans, such as guns and shoes, or in homes, such as cloth or butter, became goods produced in factories. For example, skilled armorers making complete guns gave way to armories. In the latter, semi-skilled men or boys used special purpose machines tools to produce standardized parts to assemble into guns. Compared to earlier ways of making things, factories were specialized, mechanized, capital-intensive, market-oriented, and big.[29]

At the turn of the century, engineers formulated rational management systems, as the finishing touch to this transformation. Many engineers worked on such systems but "scientific management," as propounded by Frederick W. Taylor, was the best known and, in many ways, epitomized this movement. A son of a Philadelphia aristocrat, Taylor became a mechanical engineer by apprenticing to the eminent businessman-engineer William Sellers and completing a correspondence course at the Steven's Institute of

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[29] A vast literature discusses the transition to industrial production. Fitzgerald synthesizes this literature concisely and accurately: Fitzgerald, *Yeoman No More,* 16-24. On early factory production of

Technology. A zealot for "efficiency," Taylor sought to standardize and routinize everything in a factory-machines, production processes, and, especially, workers.[30]

Taylor's general approach included tuning-up all the work processes and machinery in a factory and implementing an exceedingly detailed management regimen. To refine work processes, experts would observe and time the motions of workers. The experts then broke-down complex processes, refined movements, assigned optimal times, and provided workers with explicit instructions on how to perform tasks. Taylor tried to sweeten these changes for workers by tying the reformulated work to incentive pay scales. Refining machinery entailed replacing belting to make it uniform, installing high-speed tool steel, and arranging machinery on a factory floor so that work could flow from one to the next an so on through the factory. The most visible parts of Taylor's management reforms were planning offices. In these spaces, engineers oversaw the operations of a factory and coordinated sets of cards, which tracked items around the shop floor. Finally, Taylor called his system scientific because he believed that analysis would provide a unique "one-best-way" to reorganize a workplace and the process occurring within it.

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guns, see: Merritt Roe Smith, *Harpers Ferry Armory and the New Technology: The Challenge of Change* (Ithaca: Cornell University Press, 1977).

[30] For a description of the main elements of Taylorism and how agricultural engineers adopted them see: Fitzgerald, *Yeoman* No *More*, 93-99. Other concise discussions of Taylorism include: Layton, *Revolt of the Engineers*, 134- 153 and Thomas Hughes, *American Genesis: A Century of Invention and Technological Enthusiasm* (New York: Penguin Books, 1989), 184-203. Important longer discussions include: Hugh G. J. Aitken, *Scientific Management in Action: Taylorism at Watertown Arsenal, 1908-* 1915, 1985 ed. (Princeton: Princeton University Press, 1960); Samuel Haber, *Efficiency and Uplift: Scientific Management in the Progressive Era,* 1890-1920 (Chicago: University of Chicago Press, 1964); Daniel Nelson, *Frederick W. Taylor and the Rise of Scientific Management* (Madison: University of Wisconsin Press, 1980); and Robert Kanigel, *The One Best Way: Frederick Winslow Taylor and the Enigma of Efficiency*, *The Sloan Technology Series* (New York: Viking, 1997).

Drawing on experiences from industrialization and Taylorism, the USBR and its contractors built dams in a fully industrialized and Taylorized fashion by the 1930s. The USBR and its contractors split the tasks of building large dams. The USBR managed and refined work processes, such as pouring concrete. The contracting corporations handled the construction plant and workers.

Dam sites lacked a space labeled a planning office, but, during the construction of a dam, USBR employees primarily provided the management oversight, which Taylor placed in planning offices. The USBR used drawings and inspectors to manage construction of dams in the 1930s. For example, in building Grand Coulee Dam, the USBR created at least three distinct sets of drawings to guide the process. First, preliminary studies, such as the one conducted by Major John Butler of the Army Corps of Engineers between June 1928 and July 1931, contained a handful of general drawings to convey the concept behind a proposal.[31] For the Grand Coulee site, the printed version of Butler's report contained an 1 l-page description of a high dam and hydroelectric power plant and two drawings: one plate with a plan and an elevation for a dam cresting at elevation 1266.6 feet and one plate with sections of the same structure.[32] Second, junior engineers in the USBR's Denver office prepared a more detailed set of drawings and specifications for contractors to use in preparing bids. There were two separate

[31] In a study of the Columbia River as a whole, Butler was the first print a plan for Grand Coulee Dam substantially as it would be built. USBR engineers adopted Butler's data and analysis with very minor modifications as they worked with Washington congressmen on legislation in 1932, which ultimately failed. They again used Butler's materials when President Roosevelt approved the construction of a dam at the Grand Coulee site and told Washington congressmen to work with the USBR to develop the project. The study was published as: Committee on Rivers and Harbors, *Columbia River and Minor Tributaries,* 73rd Cong., 1st sess., 1933, H. DOC. 103.

[32] House Committee on Rivers and Harbors, *Columbia River and Minor Tributaries,* Plates 57 and 58. On studies of the Columbia Basin during the 1920s and the significance of Butler's study, see: Ellison, "Making of a Multiple Purpose Dam," 120-141.

major contracts for Grand Coulee Dam and two sets of specifications. The second document, from 1937, covered the completion of the dam from roughly low water level to its full height, the base of a facility to pump irrigation water, and one power plant to generate hydroelectricity. This document used 161 pages and 122 drawings to describe the undertaking in much greater detail than Butler.[33] Third, during the process of construction, USBR engineers in Denver made numerous detail drawings that superseded those in the specifications. Every particular of the dam would be laid out in a series of drawings. For Grand Coulee Dam, the Denver Office sent these drawings to USBR Construction Engineer Frank Banks at the site office. He, in turn, gave the drawings to the contractors. Nothing happened on the dam without authorization from Denver. For example, in January 1936 the contractors and Banks negotiated with the Denver Office over the pouring schedule for a section of the downstream edge of the dam but could not go ahead without drawings from Denver. H. Leslie Myer, the contractors' general manager, worried that any delay in pouring this section would delay the entire dam. Correspondence only gradually brought agreement on a modified plan. Banks wrote several times requesting drawings to prevent delay before the Denver engineers approved a plan and sent the illustrated guidelines.[34]

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[33] U. S. Bureau of Reclamation, ***Completion of Grand Coulee Dam, Left Powerhouse, and Foundation for*** Pumping Plant, Columbia ***Basin Project, Washington, Schedule, Specifications, and Drawings, Specifications, no.*** 757 (Denver: W. H. Kistler Stationery, 1937). See also: U. S. Bureau of Reclamation, ***Grand Coulee Dam and Power Plant, Schedule, Specifications, and Drawings, Specifications*** No. 570 ([Denver]: [U. S. Bureau of Reclamation], 1934).

[34] The task of transmitting drawings was important and general enough to require instructions on performing it. See: R. Walter to All Field Offices, 7 Mar. 1934, 774:395.30 1/30-6/45, Entry 7/30-45, WDC, RG 115 and Office Memo No. 199, 7 Feb. 1940, 774:395.30 l/30-6/45, Entry 7/30-45, WDC, RG 115. Also, Commissioner Page resisted the idea of changing these procedures for Grand Coulee Dam. See: J. Page to H. J. Kaiser, 7 June 1938, 478:101.03 1930 thru, Entry 7/30-45-CBP, WDC, RG 115. On the episode where the lack of drawings threatened to delay construction, see: H. L. Myer to F. A. Banks, 6 Jan. 1936,444:791-I 1936, EC-CB, CE, RG 115; F. A. Banks to R. Walter, 14 Jan. 1936,444:791-I 1936,

Inspectors provided the second key mechanism of engineering oversight in the Taylorist fashion by guaranteeing that contractors followed directions communicated through drawings. A USBR project office employed many inspectors who worked shifts along side construction men. Inspectors primarily oversaw the pouring of concrete for the dam and the grouting of its foundation. (Foundation grouting was a procedure in which technicians pumped very thin cement into deep holes drilled into the bedrock under a dam to seal any cracks in the rock.) Inspectors verified the quality of these operations. For example, contractors poured Grand Coulee Dam in blocks and engineers reviewed the set-up for each before pouring. First, men placed wood and metal forms capable of holding 265 cubic yards to 463 cubic yards of concrete. The largest forms measured 50 feet by 50 feet by 5 feet. Second, workers installed hardware for the block, including pipes for grout, metal sheets to manage the flow of grout in the structure, pipes to carry water to cool the concrete as it set, and pipes for drainage. Third, they cleaned the concrete and metal surfaces. This step insured that the new block bonded to those surrounding it. USBR inspectors checked the performance of all these tasks and issued an OK valid for three hours. If the contractor did not place the concrete in that time, USBR men had to re-inspect.[35]

EC-CB, CE, RG 115; F. A. Banks to R. Walter, telegram, 15 Jan. 1936,444:791-I 1936, EC-CB, CE, RG 115; F. A. Banks to R. Walter, 15 Jan. 1936,444:791-I 1936, EC-CB, CE, RG 115; R. Walter to F. Banks, telegram, 17 Jan. 1936,444:791-I 1936, EC-CB, CE, RG 115; R. Walter to F. Banks, telegram, 20 Jan. 1936,444:791-I 1936, EC-CB, CE, RG 115; F. Banks to R. Walter, 23 Jan. 1936,444:791-I 1936, EC-CB, CE, RG 115; Acting Chief Engineer S. Harper to F. Banks, 24 Jan. 1936,444:791-I 1936, EC-CB, CE, RG 115; and Acting Chief Engineer S. Harper to F. Banks, telegram, 24 Jan. 1936,444:791-I 1936, EC-CB, CE, RG 115.

[35] F. A. Banks, "Significance of Grand Coulee Dam," ***The Reclamation Era*** 26 (December 1936): 278-9 and "Handling Concrete...In the Blocks at Coulee," ***Pacific Builder and Engineer*** 45 (5 August 1939): 26, 27, 65.

The Taylorist style of management conducted by the USBR matched the extensively mechanized, flow-oriented, and capital-intensive construction plant erected by the contractors. The contractors employed partially or completely mechanized systems to remove the dirt, rock, and debris down to bedrock at the dam site; to prepare materials for and mix concrete; and to convey concrete to the dam. Unwanted materials flowed out of the site and needed ones flowed into it. To clear the dam site, contractors brought in a fleet of shovels, bulldozers, and dump trucks. The trucks moved debris to a conveyor system with four 60-foot feeder belts serving a mile long main belt, which transported materials to Rattlesnake Canyon. After clearing the dam site, producing and placing concrete dominated construction. The basic components of concrete are gravel, sand, cement, and water. Contractors mined gravel and sand at a location 1.5 miles from the dam site. From pits, a mechanized system washed, screened, and separated the raw materials into three grades of sand, four grades of gravel, and waste. Two automated concrete mixing plants-one of each side of the river-combined sand, gravel, cement that had arrived by rail, and water in set ratios to make concrete. Locomotives hauled buckets of concrete from the mixing plants onto a trestle over the dam. Crane operators, high above the dam, picked up the buckets and swung them down to the next block to be filled. At the block, men dumped the buckets and urged the concrete into place with electrical vibrators.[36]

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[36] The construction magazine *Pacific Builder and Engineer* covered the construction of Grand Coulee Dam in detail. Major articles on the construction plant include: Walter A. Averill, "Moving a Mountain a Mile.. .at Grand Coulee," ***Pacific Builder and Engineer*** 41 (12 October 1935): 28-38; Robert J. Jenks, "Producing Aggregate for the World's Largest Concrete Structure," ***Pacific Builder and Engineer*** 41 (7 December 1935): 26-32; "Manufacturing 4,500,000 c. y. of Concrete for Coulee Dam," ***Pacific Builder and Engineer 42 (4*** January 1936): 30-36; "Handling Concrete"; and "Cranes are Vital Cog in Placing Concrete at Coulee," ***Pacific Builder and Engineer*** 45 (2 September 1939): 36-39.

In addition to Taylorist oversight of production and a Taylorist mechanized, flow-oriented, capital-intensive workplace, the USBR employed experts to study and refine work processes, much as Taylor and his colleagues used time and motion studies to modify workers' performance. USBR men, however, could not analyze workers. In 1911, molders struck the Watertown Arsenal when Carl Barth, one of F. W. Taylor's inner circle, attempted to reorganize the foundry. Ultimately, Congress banned the use of stop watches to analyze workers and incentive pay systems in federal workplaces. Instead of workers, USBR men took on machinery. Work with cement mixers exemplified this impulse to refine. The two plants for making concrete-Westmix and Eastmix-each had four mixers that could each hold four cubic yards (a total of 32 cubic yards). During the winter of 1936-7, USBR engineers and the contractors' men collaborated on redesigning these mixers to increase mixing speed. They built model mixers of one-thirteenth capacity and tested them at a laboratory at the Grand Coulee Dam site. The USBR engineers tested between fifty and sixty different arrangements of mixer blades seeking the shortest time to produce a uniform product. The best design reduced nine blades to three and reoriented them. These new arrangements shortened mix and discharge time by 16 percent. Since the second contract alone required mixing 5,800,000 cubic yards of concrete thirty-two cubic yards at a time, this timesaving was substantial.[37]

While the comparison of a factory floor and a construction site is fairly direct, an analogy between a factory floor and a river is necessarily much more abstract. At the

[37] "Manufacturing Concrete" and Fred K. Ross, "Mixing Time Reduced at Grand Coulee: Reclamation Bureau Works out New Blading Arrangement for Mixers," ***Pacific Builder and Engineer 44*** (5 November 1938): 28-29.

damsite, USBR engineers provided expert oversight, the contractors built a mechanized and rationalized construction plant, and the two groups worked together to investigate ways to refine the equipment. Similarly, Taylorism experts implemented planning offices, organized shop floors, and tuned up processes, machinery, and workers. With multiple purpose dam building, federal engineers combined ideas about river development advocated by Progressive Era conservationists with analysis and management techniques similar to Taylorism.

While engineers formulated around scientific management, a broader group of scientists, engineers, and politicians brought conservation to the fore as a set of "scientific" ideas to govern the management of natural resources during the Progressive Era. Championed by forester and politician Gifford Pinchot, conservation called for the maximum sustained use of natural resources, such as forests, grazing lands, rivers, and oil and mineral deposits. As with scientific management, technical experts-engineers, foresters, geologists, etc-implemented the programs to achieve the goals of conservation. Conservationists called for two major changes in river development. Comprehensive planning provided schemes that combined navigation, flood control, irrigation, hydroelectricity, and other improvements. Construction of reservoirs captured seasonal floods and made "waste water" into a critical supplement to water supply in arid regions.[38]

[38] The definitive work on federal conservation in the Progressive Era is: Samuel P. Hays, *Conservation and the Gospel of Efficiency: The Progressive Conservation Movement, 1890-1920, Harvard Historical Monographs,* v. 40 (Harvard: Harvard University Press, 1959). See also: Clayton R. Koppes, "Efficiency, Equity, Esthetics: Shifting Themes in American Conservation," in *The Ends of the Earth: Perspectives on Modern Environmental History,* ed. Donald Worster (Cambridge: Cambridge University Press, 1988), 230-251; Joseph M. Petulla, *American Environmentalism: Values, Tactics, Priorities, Environmental history series, no.* I (College Station: Texas A&M University Press, 1980), 34-39; and J. Leonard Bates, "Fulfilling American Democracy: The Conservation Movement, 1907 to 1921," *Mississippi*

In order to implement conservation ideas about river development, in a Taylorist style, federal engineers began by measuring rivers. Rather than stop watches, engineers, like John Butler, used gaging stations, topographical maps, and geological assessments of potential dam sites to assess the river's current practice and as a basis for constructing a new "rational" river. Butler invested over half of his funds for studying the upper Columbia River (the river above its confluence with the Snake River) in collection of data and preliminary analysis of water supply, topography, geology, and land classification. Gaging produced quantitative data on the monthly discharge at 2 1 locations and on the stages of five lakes. Topography provided an overall profile of the river. Finer topography and core drilling (removing columns of rock to assess the structures) provided more specific data on 12 potential dam sites. Land classification ranked land near the river by its quality for irrigation farming.[39]

To redesign the river, as Taylor redesigned workers' movements and machinery, Butler combined this information with broad conservationist goals. Butler began with the canonical conservation goal for river development: the intention to consider all of the possible uses of water and their interactions. Butler stated:

> The purpose of this report is to formulate plans for the most effective improvement of Columbia River for the purposes of navigation, and for combining such improvement with the most efficient development of the potential water electricity, the control of floods, and the needs of irrigation.@

Adapting this general mandate to the Columbia River, Butler quickly concluded that production of hydroelectricity and irrigation of the Columbia Basin, a large arid area

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Valley Historical Review 44 (1958): 29-57. On conservation ideas as applied to waterways see: Ellison, "Making of a Multiple Purpose Dam," 105-120.

[39] House Committee on Rivers and Harbors, *Columbia River and Minor Tributaries, 566-572.*

[40] House Committee on Rivers and Harbors, *Columbia River and Minor Tributaries*, *566.*

southwest of Spokane, Washington, would be the most valuable uses of the upper Columbia River. Navigation was unlikely to be cost effective and the upper river had few flooding problems. With knowledge of the water supply and an assessment of water needs, Butler set aside water for the irrigation of the Columbia Basin. He then used knowledge of topography and geology to identify a set of dams that would allow full use of the remaining water for producing hydroelectricity. Butler sketched a plan in which each dam backed water to the foot of the next, so that all the potential energy created by change in elevation could be converted into hydroelectricity. This approach gave rivers planned in the early twentieth century a characteristic stair-step, or chain-of-lakes, profile-the conservationists' "one-best-way" to develop a river. Geology narrowed the possible dam sites to those suited to hold large structures. Ultimately, Butler proposed five hydroelectric dams; an electricity and irrigation project at the head of the Grand Coulee; three storage reservoirs in the headwaters of tributaries to the Columbia River; and two sets of locks and lateral dams to improve navigation, if increased river use justified these last structures at some point.[41]

Butler, his staff, and his counterparts in the USBR provided the expertise, called for by both Taylor and conservationists. Butler headed 18 men from five fields who conducted the upper Columbia River study. Butler's acknowledgements indicated a permanent staff of eight men: five members of the American Society of Civil Engineers, two members of the American Institute of Electrical Engineers, and one man identified simply as an irrigation engineer. Butler also drew on the advice of 10 consultants: four civil engineers, two electrical engineers, three geologists, and one economist. Similarly,

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[41] House Committee on Rivers and Harbors, *Columbia River and Minor Tributaries,* 1058-1067.

the USBR placed studies of potential new irrigation projects in the hands of a senior field engineer and a small staff. Men from the Denver office often provided consulting services on dam design and in other areas.[42]

While field staff analyzed and refined the river, the Denver office specialized in analyzing and refining the main technology of multiple purpose river development-dams. During the 1920s and 1930s as the Denver office grew, it substantially expanded investigation and analysis. First, the USBR developed two methods for analyzing stresses and strains in dams. Using mathematics, USBR engineers developed the trial-load method of analyzing arch dams as part of designing Hoover Dam, When a dam curves from side to side, as Hoover Dam does, some or all of the weight of the water behind the dam is transmitted to the abutments (canyon sides) through arch action, rather than to the foundation under the dam by gravity effects. Trial-load analysis provided a more accurate approach to calculating the extremely complicated stresses and strains in a potential structure due to this dual distribution of forces. In parallel with trial-load analysis, USBR engineers developed a program of photoelastic analysis using models to determine stresses and strains on potential structures. Beginning in 1927, the USBR built models of dams at a facility at the University of Colorado in Boulder. The engineers constructed the earliest models-those of Stevenson Creek Test Dam and Gibson Dam-out of concrete and used a rubber pouch filled with mercury to simulate the weight of a reservoir. They used optical instruments and a system of gages to measure stress and strain in the models. For Grand

[42] House Committee on Rivers and Harbors, *Columbia River and Minor Tributaries,* 1067.

Coulee Dam, the combination of mathematical and photoelectric analyses led USBR men to add twist adjustment slots near each abutment to reduce twist forces in the structure.[43]

The second major experimental program for refining dam technology developed in this period used hydraulic models. Building on a European tradition, USBR men began making models of dams in metal and wooden beds and running water over them to observe the qualitative effects of elements of the structure on water flow. The USBR men located their first laboratories at Colorado State College (now University) in Fort Collins and in Montrose, CO. For Grand Coulee Dam, the USBR men used hydraulic experiments to refine the "toe" of the dam. At the downstream edge of Grand Coulee Dam, the structure must dissipate the substantial energy of a large river pouring off a 430-ft prism of concrete. The shape of the toe determines whether the water digs a hole under the dam, digs at the dam's edge, geysers up in the air, boils and then joins the flow at the base of the dam, or any number of better and worse possibilities. After observing models of several different options, engineers chose a curved toe with a 50-foot diameter bucket for the base of Grand Coulee Dam. USBR men also used a hydraulic model to plan the order of pouring Grand Coulee Dam. This work reduced the damage to the riverbanks above and below the dam site caused by the hydraulic characteristics of the partly complete structure.[44]

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[43] Ivan E. Houk, "Experimental Work on Small-Scale Models of Arch Dams," *New Reclamation Era* 18 (October 1927): 152-154; Elwood Mead, "Research Work of the Bureau of Reclamation," *Reclamation Era 24* (May 1933): 54-55, 57; J. L. Savage, "Dam Stresses and Strains Studied by Slice Models," *Engineering News-Record* 113 (6 December 1934): 720-723; Ivan E. Houk, "Twist Effects in Straight Gravity Dams," *Engineer* 164 (24 December 1937): 702-705; and McMechen, "Billion Dollar Engineer."

[44] Jacob E. Warnock, "Experiments Aid Design at Grand Coulee," *Civil Engineering* 6 (November 1936): 737-41 and D. P. Barnes, "Hydraulic Models Aid Design of Reclamation Structures," *Reclamation Era* 27 (February 1937): 34-5.

Finally, the USBR used a materials laboratory to tune up dams. The primary work of this facility was concrete analysis. Originally located at the University of California, USBR men and their academic collaborators studied cement and concrete to reduce shrinkage during drying, which could cause uneven distribution of forces and cracks in a structure. Out of such work, USBR men developed a system of embedding thin water pipes throughout very large structures to speed concrete cooling. They also wrote new specifications for cement.[45]

Gazing at the world with vision sharpened by engineering training, USBR leaders saw disorderly construction sites and disorderly rivers. They drew on the experiences and enthusiasms of their profession-industrialism, Taylorism, and conservation-to fix the problems they saw. Construction sites looked a lot like a factory floor where engineers could be put in charge, work could be mechanized and made to flow, and components could be analyzed and tuned for speed. USBR engineers placed themselves at the metaphorical center managing construction with drawings and inspections. From removing dirt to delivering concrete, contractors, such as Morrison-Knudsen and H. J. Kaiser, used trucks, conveyor belts, and cranes to make materials flow out of and into dam sites. USBR engineers and contractors collaborated to analyze not workers but machines, such as concrete mixers, to tune-up and speed work.

Rivers looked less like factories. Still, USBR leaders fused ideas from conservation and Taylorism in the planning and building of the first generation of multiple purpose dams. As with Taylor and his program, USBR engineers placed experts in control, analyzed and rationalized both processes and components, and believed single

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[45] Mead, “Research Work”; McMechen, “Billion Dollar Engineer”; and “Designs and

“best” solutions existed for the problems they tackled. They used the conservation concepts of comprehensive planning and increasing water supplies through storage as the framework in which to seek Taylorist solutions. First, groups of engineers gaged water supply, mapped terrain, examined beds of rivers, and classified lands. They used this analytic deconstruction and the concept of comprehensive planning to create a new water system tuned to supply the water resources in a single best way. For example, the whole Columbia River, reconceptualized as a signature chain-of-lakes, would use 92% of possible head for an installed capacity to produce 8.5 million kilowatts of electricity while providing water to irrigate 1.6 million acres and providing a 9-foot navigation channel 200 miles inland along the Washington-Oregon boarder.[46] Second, engineers turned their rationalizing attention to dams, the technological backbone of new rivers. For dam building, they conducted mathematical and experimental analyses to maximize desired performance-a safe structure with good hydrodynamics-while minimizing cost.

Conclusions

In this paper, I have demonstrated that between 1923 and 1943 a very stable and uniform group of engineers with a Progressive pedigree led the USBR. I have also suggested that the significance of this finding lies in the ways that these men drew on the experiences and enthusiasms of engineering, especially industrialization, Taylorism, and conservation, as the USBR grew and instituted multiple purpose dam building. In the Taylorist fashion, USBR men created central managerial spaces for themselves, analyzed

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Specifications,” *Reclamation Era 30* (July 1940): 192.

and rationalized large processes and their components, and undertook this work with a faith that it would produce unique optimal solutions. They did this to both dam construction sites and to the planning of water resources. In the latter, USBR leaders fused Taylorism and conservation to take multiple purpose dam building from an idea to a reality.

Philosophers of science traditionally end papers with a promissory note that acknowledges important areas for future research. While I am no philosopher, I would like to note that the second part of this paper suggests an important area for additional research. The USBR was certainly not the only dam builder in this period nor the only one to employ industrialized and Taylorized construction plants. A broader consideration of the technologies and industrialization of dam construction would trace the shift from brick or stone and mortar dams built primarily using animal and human power to concrete dams whose construction relied on internal combustion engines and electricity.

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[46] House Committee on Rivers and Harbors, ***Columbia River and Minor Tributaries,*** 6-15.

Table 1: Sources on engineers		
Name	*Office*	*Source*
Banks, Frank Arthur	Field	"Banks, Frank Arthur." In *Who Was Who in America, Vol. 3*, 47. Chicago: Marquis Who's Who, 1960.
Bashore, Harry	WDC	"Bashore, Harry William." In *Who Was Who in America with World Notables, Vol. 5*, 42. Chicago: Marquis Who's Who, 1973.
Bien, Morris	WDC	"Morris Bien." *Reclamation Record* 6 (March 1915): 121 and "Morris Bien 1859-1932." *Reclamation Era* 23 (August 1932): 147.
Bissell, Charles A.	WDC	"Charles A. Bissell Retires with Honors." *Reclamation Era* 42 (February 1952): 45.
Boden, Oscar G.	Field	Goodman, D. L. "Oscar G. Boden--Builder of Lifelines: Reclamation's Hall of Fame Nomination No. 12." *Reclamation Era* 42 (February 1952): 30-31, 38.
Brown, Hugh A.	WDC	Davis, A. P. "The Editor of the Reclamation Record." *Reclamation Record* 7 (October 1916): 469-70 and "Hugh Arbuthnot Brown, 1877-1932." *Reclamation Era* 23 (September 1932): 157.
Bunger, Mills Emerson	Field	"Bunger, Mills Emerson." In *Who's Who in the West*, 98. Wilmette, IL: Marquis Who's Who, 1980.
Burch, Albert Nelson	Field	Perkins, W. A. "Albert Nelson Burch, M. ASCE." *ASCE Transactions* 101 (1936): 1532-1533.
Calland, Robert S.	Field	"Appointments and Retirements." *Reclamation Era* 47 (February 1957): 19.
Cole, C. M.	Field	"C. M. Cole." *MWAK Columbian* (24 July 1936): 3.
Crowe, Francis Trenholm	Denver	Harper, S. O., Walker R. Young, and W. V. Greeley. "Francis Trenholm Crowe, Hon. M. ASCE." *ASCE Transactions* 113 (1948): 1397-1403.
Darland, Alvin F.	Field	Alvin F. Darland to James O'Sullivan, 20 September 1933, 29:Personnel 1933, Columbia Basin Commission Papers, Washington State Archives, Olympia, Washington.
Davis, David W.	WDC	"Davis, David William." In *The National Cyclopaedia of American Biography, Vol. 46*, 435-436. New York: James T. White and Company, 1963.
Day, C. M.	Denver	"C. M. Day, Chief Mechanical Engineer, Denver, Dies." *Reclamation Era* 27 (March 1937): 68.
Debler, Erdman B.	Denver	"Debler, Erdman B." In *Who Was Who in America, Vol. 7*, 147. Chicago: Marquis Who's Who, 1981.
Dibble, Barry	Denver	"Dibble, Barry." In *Who Was Who in America, Vol. 4*, 248. Chicago: Marquis Who's Who.
Golze, Alfred Rudolf	WDC	"Golze, Alfred Rudolf." In *Who's Who in America*, 1236. Wilmette, IL: Marquis Who's Who, 1978.
Harper, Sinclair Ollason	Denver	"Harper, Sinclair Ollason." In *Who Was Who in America, Vol. 7*, 255. Chicago: Marquis Who's Who, 1981.
Hinds, Julian	Denver	"Hinds, Julian." In *Who Was Who in America, Vol. 6*, 194. Chicago: Marquis Who's Who, 1976.
Houk, Ivan	Denver	McWhinnie, Robert C. "Ivan Edgar Houk, F. ASCE." *Transactions of the ASCE* 138 (1973): 628-629.
Keener, Kenneth Bixby	Denver	"Honorary Degrees Conferred on Reclamation Officials." *Reclamation Era* 30 (September 1940): 262-263.
Koppen, Charles Edward	Field	"Edward Charles Koppen 1879-1940." *Reclamation Era* 31 (January 1941): 13.
Kreutzer, George Charles	WDC	Mead, Elwood, and R. F. Walter. "George Charles Kreutzer, M. ASCE." *ASCE Transactions* 95 (1931): 1526-1528.
Lowry, Ralph	Field	"Lowry, Ralph." In *Who Was Who in America with World Notables, Vol. 8*, 253. Chicago: Marquis Who's Who, 1985.
McCasland, Stanford Paul	Field	"McCasland, Stanford Paul." In *Who's Who in the West*, 478. Wilmette, IL: Marquis Who's Who, 1980.
McClellan, Leslie Newman	Denver	"McClellan, Leslie Newman." In *Who Was Who in America with World Notables, Vol. 8*, 268. Chicago: Marquis Who's Who, 1985.
McPhail, Harvey Franklin	Denver	"McPhail, Harvey Franklin." In *Who Was Who in America, Vol. 9*, 244. Chicago: Marquis Who's Who, 1989.

Mead, Elwood	WDC	"Mead, Elwood." In *The National Cyclopaedia of American Biography, Vol. 26*, 44-45. New York: James T. White and Company, 1937; Conkin, Paul K. "The Vision Of Elwood Mead." *Agricultural History* 34 (April 1960): 88-97; and Kluger, James R. *Turning on Water with a Shovel: The Career of Elwood Mead.* Albuquerque: University of New Mexico Press, 1992.
Miner, James Henry	Field	Sharkey, Fred J. "James Henry Miner, Assoc. M. ASCE." *ASCE Transactions* 109 (1944): 1576-1577.
Mitchell, L. H.	WDC	"L. H. Mitchell Dies." *Reclamation Era* 46 (May 1956): 50.
Monroe, Robert Ansley	Denver	"Monroe, Robert Ansley." In *Who Was Who in America, Vol. 8*, 286. Chicago: Marquis Who's Who, 1985.
Moore, John S.	Denver	"John S. Moore Promoted." *Reclamation Era* 31 (February 1941): 50.
Moritz, Ernest A.	Field	"Moritz, Ernest A." In *Who Was Who in America, Vol. 7*, 414. Chicago: Marquis Who's Who, 1981.
Munn, James	Denver	"James Munn, 1865-1939." *Reclamation Era* 29 (June 1939): 155.
Nalder, William H.	Denver	"Bureau Design Engineer Ends 43 Years Service." *Engineering News-Record* 149 (30 October 1952): 52.
Neeley, Parley R	Field	"Neeley, Parley R." In *Who's Who in Engineering*, edited by Gordon Davis, 577. Washington, D.C.: American Association of Engineering Societies, 1988.
Nelson, Wesley P.	WDC	"New Appointments in the Bureau of Reclamation: Roy B. Williams, J. Kennard Cheadle, and Wesley P. Nelson." *Reclamation Era* 27 (September 1937): 200-201.
Nielsen, Edwin George	Field	"Nielsen, Edwin George." In *Who's Who in America*, 2402. Wilmette, IL: Marquis Who's Who, 1978.
Page, John Chatfield	WDC	"Page, John Chatfield." In *Who Was Who in America, Vol. 3*, 660. Chicago: Marquis Who's Who, 1960.
Parker, Horace A.	Field	"H. A. Parker Now Irrigation Engineer, Columbia Basin Project." *Reclamation Era* 29 (January 1939): 20.
Preston, Porter Johnstone	Field	"Porter J. Preston Retires." *Reclamation Era* 31 (1941): 51 and "Preston, Porter Johnstone." In *The National Cyclopaedia of American Biography, Vol. 39*, 356. New York: James T. White and Company, 1954.
Rawn, A. M.	Field	"Rawn, A. M." In *The National Cyclopaedia of American Biography, Vol. 55*, 194-195. New York: James T. White and Company, 1974 and "Rawn, A. M." In *Who Was Who in America with World Notables, Vol. 8*, 332. Chicago: Marquis Who's Who, 1985.
Savage, John Lucian	Denver	McMechen, Edgar C. "The Billion Dollar Engineer." *Reclamation Era* 27 (April 1937): 82-84; *John Fritz Medal: Biography of John Lucien Savage, Medallist for 1945.* New York: John Fritz Medal Board, 1945; "Savage, Dr. John Lucian." In *American Men of Science, 11th edit.*, 4669. New Providence, NJ: R. R. Bowker, 1968; Wolman, Abel and W. H. Lyles. "John Lucian Savage." In *Biographical Memoirs: National Academy of Sciences, Vol. 49*, 225-239. Washington, D. C.: National Academy of Sciences, 1978; and Rhodes, Benjamin D. "From Cooksville to Chungking: The Dam-Designing Career of John L. Savage." *Wisconsin Magazine of History* 72 (1989): 243-272.
Schnurr, Mae A.	WDC	Pfaff, Christine. "Mae Schnurr: A Woman's Rise to Prominence." *Prologue* 29 (Fall 1997): 232-242.
Sharkey, F. J.	Field	"F. J. Sharkey." *MWAK Columbian* (31 July 1936): 3.
Snell, Roy Martin	Field	Given, J. A. "Roy Martin Snell, M. ASCE." *ASCE Transactions* 106 (1941): 1679-1680.
Walker, Albert Willard	Field	Hosig, Irwin B. and H. P. Wangen. "Albert Willard Walker, Assoc. M. ASCE." *ASCE Transactions* 109 (1944): 1580-1582.
Walter, Raymond Fowle	Denver	"Walter, Raymond Fowler." In *Who Was Who in America, Vol. 1*, 1295. Chicago: The A. N. Marquis Company, 1942.
Weiss, Andrew	Denver	"Andrew Weiss." *Civil Engineering* 43 (January 1949): 55-6.
Weymouth, Frank Elwin	Denver	"Weymouth, Frank Elwin." In *Who Was Who in America, Vol. 1*, 1326. Chicago: The A. N. Marquis Company, 1942.
Williams, Charles Page	Denver	"Williams, Charles Page." In *Who Was Who in America, Vol. 3*, 920. Chicago: Marquis Who's Who, 1950.

Williams, Roy B.	WDC	"New Appointments in the Bureau of Reclamation: Roy B. Williams, J. Kennard Cheadle, and Wesley P. Nelson." *Reclamation Era* 27 (September 1937): 200-201 and "Gold Medals for Enginers [sic] Williams and Patch." *Reclamation Era* 39 (December 1949): 233.
Young, Walker Rollo	Denver	"Young, Walker Rollo." In *Who Was Who in America with World Notables, Vol. 7,* 633-634. Chicago: Marquis Who's Who, 1981.

Table 2: Abbreviations used in footnotes	
CE	Office of the Chief Engineer, Denver, Colorado, RG 115
EC-CB	General Correspondence Files 1902-42 (Engineering), Columbia Basin, CE, RG 115
Entry 10	Entry 10 Project Histories, Feature Histories, and Reports 1902-1932, WDC, RG 115
Entry 7/30-45	Project Correspondence File 1930-1945, Entry 7 General Administrative and Project Records 1919-1945, WDC, RG 115
Entry 7/30-45-CBP	Project Correspondence File 1930-1945, Columbia Basin Project, Entry 7 General Administrative and Project Records 1919-1945, WDC, RG 115
RG 115	Records of the Bureau of Reclamation, Record Group 115, National Archives-Rocky Mountain Region, Denver, Colorado
WDC	Office of the Commissioner, Washington, D. C., RG 115
Citations to collections may include box number, box and folder numbers, or box number and file name. This information will come after the document information and prior to the collection information. It will be abbreviated box number:file designation (e.g., 3 or 3:21 or 3:Monthly Reports).	